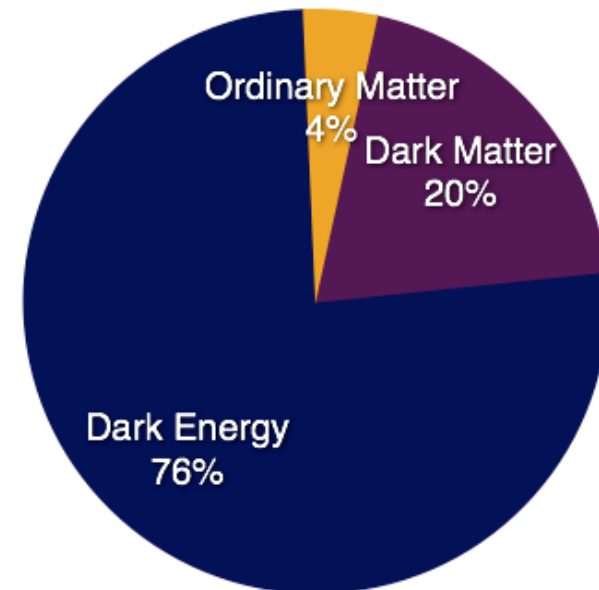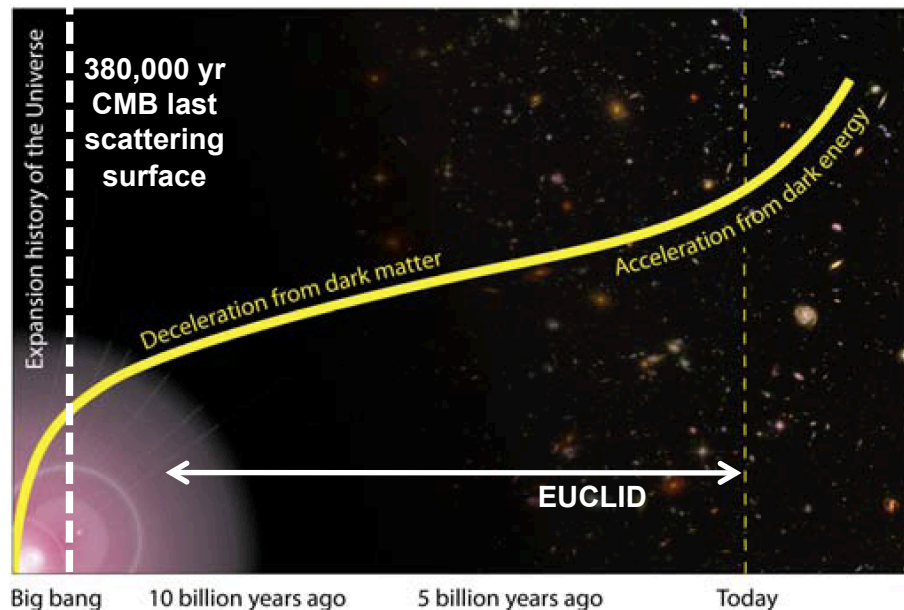# Euclid

Mapping the geometry of the Dark Universe

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See Euclid Assessment phase report
ArXiv:0912.0914

- Nature of the Dark Energy

- Nature of the Dark Matter

- Initial conditions (Inflation Physics)

- Modifications to Gravity

→ Euclid's Primary Science Objectives

# Euclid concept

- High-precision survey mission to map the geometry of the Dark Universe

- Optimized for two complementary cosmological probes
  - Weak Gravitational Lensing
  - Baryonic Acoustic Oscillations

  Additional probes: clusters, redshift space distortions, ISW

- Full extragalactic sky survey with 1.2m telescope at L2:
  - Imaging:

    High precision imaging at visible wavelengths

    Photometry/Imaging in the near-infrared
  - Near Infrared Spectroscopy

- Synergy with ground based surveys

- Legacy science for a wide range of areas in astronomy

- Survey Data public after one year

**Mission elements:**

- L2 Orbit
- 4-5 year mission
- Telescope: three mirror astigmat (TMA) with 1.2 m primary
- Instruments:
  - VIS: Visible imaging channel: 0.5 deg$^2$, 0.10'' pixels, 0.18'' PSF FWHM, broad band R+I+Z (0.5-0.9mu), 36 CCD detectors, galaxy shapes
  - NISP: NIR channel: 0.5 deg$^2$, 16 HgCdTe detectors, 0.9-2.0mu:
    - Photometry: 0.3'' pixels, 3 bands Y,J,H, photo-z's
    - Spectroscopy: slitless, R=350, redshifts

# Euclid Surveys

**Wide Survey:** 20,000 deg$^2$

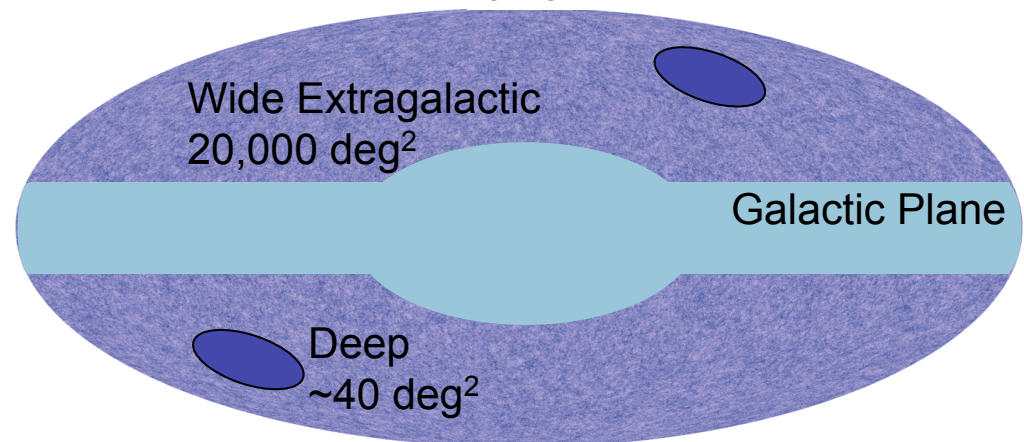- Visible: Galaxy shape measurements fro $2.10^9$ galaxies to $RIZ_{AB} \leq 24.5$ (AB, 10σ) at 0.16" FWHM, yielding 30-40 resolved galaxies/amin$^2$, with a median redshift $z \sim 0.9$

- NIR photometry: Y, J, H ≤ 24 (AB, 5σ PS), yielding photo-z's errors of 0.03-0.05(1+$z$) with ground based complement (PanStarrs-2, DES, etc)

- Spectroscopy: redshifts for $70.10^6$ galaxies with emission line fluxes $>3.10^{-16}$ ergs/cm$^2$/s at 0.5<z<2 (slitless)

**Deep Survey:** 40 deg$^2$

- Monitoring of PSF drift (40 repeats at different orientations over life of mission)

- Produces +2 magnitude in depth for both visible and NIR imaging data.

**Possible additional Galactic surveys:**

- Short exposure Galactic plane
- High cadence microlensing extra-solar planet surveys



Wide Extragalactic 20,000 deg$^2$

Galactic Plane

Deep ~40 deg$^2$

| | $\Delta w_p$ | $\Delta W_a$ | $\Delta \Omega_m$ | $\Delta \Omega_\Lambda$ | $\Delta \Omega_b$ | $\Delta \sigma_8$ | $\Delta n_s$ | $\Delta h$ | DE FoM |
|---|---|---|---|---|---|---|---|---|---|
| Current +WMAP | 0.13 | - | 0.01 | 0.015 | 0.0015 | 0.026 | 0.013 | 0.013 | ~10 |
| Planck | - | - | 0.008 | - | 0.0007 | 0.05 | 0.005 | 0.007 | - |
| Weak Lensing | 0.03 | 0.17 | 0.006 | 0.04 | 0.012 | 0.013 | 0.02 | 0.1 | 180 |
| Imaging Probes | 0.018 | 0.15 | 0.004 | 0.02 | 0.007 | 0.009 | 0.014 | 0.07 | 400 |
| Euclid | 0.016 | 0.13 | 0.003 | 0.012 | 0.005 | 0.003 | 0.006 | 0.020 | 500 |
| Euclid +Planck | 0.01 | 0.066 | 0.0008 | 0.003 | 0.0004 | 0.0015 | 0.003 | 0.002 | 1500 |
| Factor Gain | 13 | >15 | 13 | 5 | 4 | 17 | 4 | 7 | 150 |
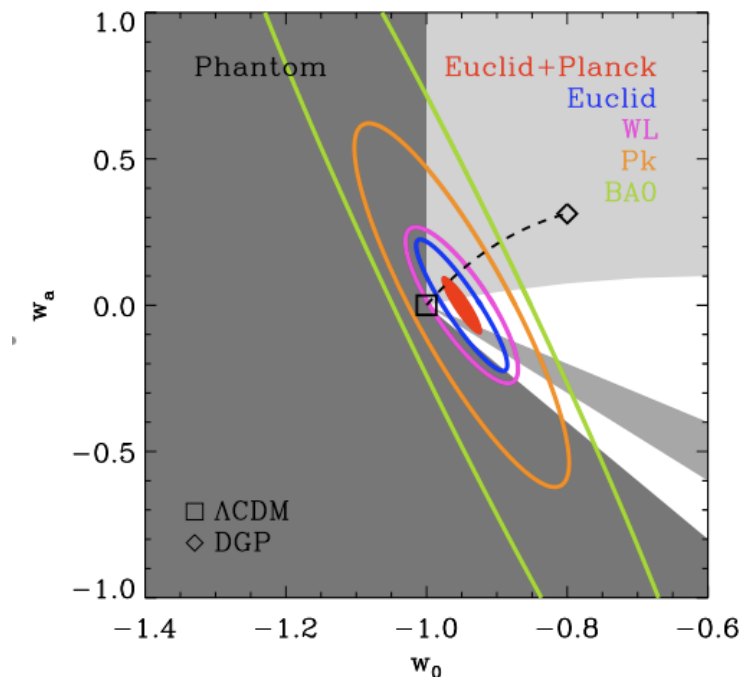


Euclid Imaging will challenge all sectors of the cosmological model:

  Dark Energy: $w_p$ and $w_a$ with an error of 2% and 13% respectively (no prior)

  Dark Matter: test of CDM paradigm, precision of 0.04eV on sum of neutrino masses (with Planck)

  Initial Conditions: constrain shape of primordial power spectrum, primordial non-gaussianity

  Gravity: test GR by reaching a precision of 2% on the growth exponent $\gamma$ ($d\ln\delta_m/d\ln a \propto \Omega_m{}^\gamma$)

→ Uncover new physics and map LSS at 0<z<2: Low redshift counterpart to CMB surveys

EUCLID

- Unique legacy survey: 2 billion galaxies imaged in optical/NIR to mag 24, 70 Million NIR galaxy spectra, full extragalactic sky coverage, Galactic sources
- Unique datase for various fields in astronomy: galaxy evolution, search for high-z objects, clusters, strong lensing, brown dwarfs, exo-planets, etc
- Synergies with other facilities: JWST, Planck, Erosita, GAIA, DES, Pan-STARSS, LSST, etc
- All data publicly available through a legacy archive
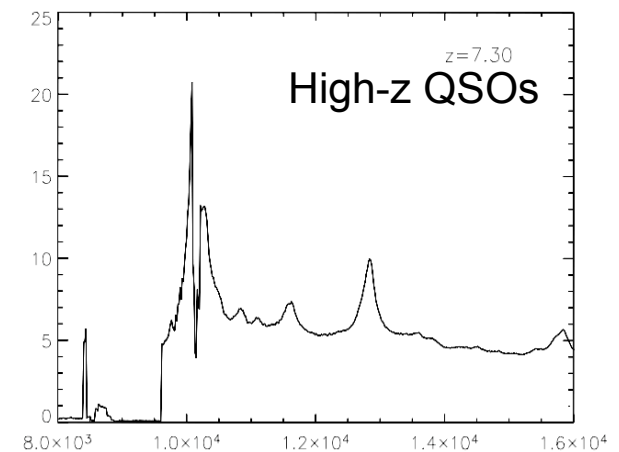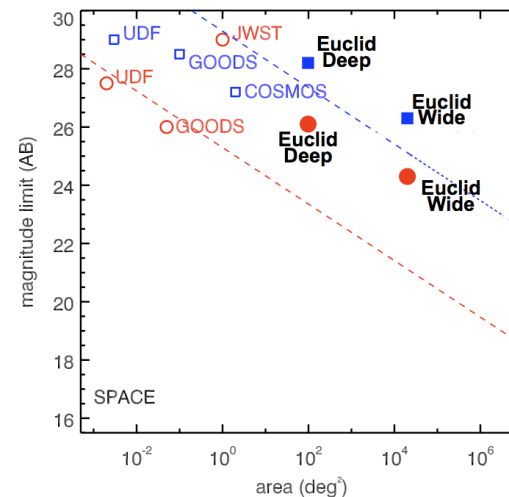
- 2004: Dark Universe Mission proposed as a Theme to ESA's Cosmic Vision programme
- 2006: Recommendation of ESO/ESA Working Group on Fundamental Cosmology
- Oct 2007: DUNE and SPACE jointly selected for an ESA Assessment Phase
- May 2008: Validation of the merged concept *Euclid* by the ESA AWG
- Sept 2008: Recommendation from Astronet Infrastructure Roadmap report
- Sept 2008-Sept 2009: Assessment study phase
- 2010-2011: Definition phase
- March-May 2010: Baseline optimisation with EOAT (merging of NIP and NIS)
- July 2010: Definition phase ESA AO (due Oct 2010)
- February 2011: Formation of Euclid Science Team
- Mid 2011: M1/M2 Cosmic Vision Selection
- 2012-2017: Implementation phase (if selected)
- 2017-2018: ESA launch of the Cosmic Vision M1/M2 missions

EUCLID

- Euclid is a high-precision wide-field survey mission to map the geometry of the Dark Universe

- Euclid will provide unprecedented accuracy on all sectors of the cosmological model: Dark Energy, Dark Matter, Initial Conditions, Gravity

- Euclid will also provide unique legacy science from its all sky legacy archive and additional surveys

- Complementary and analogous to CMB measurement of Large-Scale Structure at matter-radiation transition epoch: Euclid will provide high-precision map of LSS at matter-DE transition epoch: 3D, non-gaussian, multi-probe